Campbell 2.f.5
(1-26).

To J. F. Campbell
From his affect. & benighted Cousin
Anti-Erosion

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

On the GRANITIC DISTRICT *of* INVERARY, ARGYLLSHIRE.

By the DUKE OF ARGYLL, F.G.S.

[Read April 6, 1853*.]

THE whole area of the county of Argyll, with the exception of its islands and a mere strip along its outer coast-line, is occupied by the metamorphic rocks, with occasional masses of granite. On one portion of the mainland of the county, adjacent to the island of Mull, there is a large development of trap; and over the whole of the county there are to be seen frequent dykes of the same material, intersecting the strata in various directions.

But, with the exception of the localities already mentioned, I have seen no vestige, in any part of Argyllshire, of any of the palæozoic or secondary rocks. Nor is it probable that their absence is due to denudation, as in this case fragments would remain either amidst the masses of transported material, which are common on the surface, or —like the Old Red Sandstone along the external coast—preserved, *in situ*, among the intricacies of the hills. It would rather appear, therefore, that the mountainous district of this part of Scotland had already raised its head above the earliest seas which have yielded in their deposits the remains of life.

I need hardly say, therefore, that the geology of the county is wanting in that element which not only gives to geology the greatest interest as a study, but is the chief foundation of its certainty as a science.

When we have to deal with the Azoic rocks, nothing remains for us to elucidate but that which, as yet, is the obscurest branch of geology, I mean its mechanics;—a branch, however, on which we have every reason to hope that the science and researches of our late President will continue to cast new and important lights.

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* For the account of this evening's Proceedings, *vide supra*, p. 134.

I venture to lay before the Society some observations upon the phænomena of a certain district in Argyllshire, with which, from residence, I am particularly acquainted, in the hope that they may possibly suggest some idea of the conditions or forces which seem to have determined the position, arrangement, and mineral character of the metamorphic strata as there developed.

The first feature in the general structure of the country, which is, I think, well worthy of notice, is one which belongs not only to the district I have just referred to, but, so far as I have been able to observe, to the whole county. It is the great spaces over which one uniform line of dip is preserved by the strata of the mica-slate; a dip which has no reference to any apparent intrusive rocks, but which, on the contrary, only changes where these rocks effect the alteration. The general strike-direction of the Argyllshire strata is that which is so prominently marked on the Map of Scotland by its deeply indented western coast, viz. from N.E. to S.W.; whilst the dip in one system of valleys is N.W., and in another S.E. Thus, on the Argyllshire shore of the basin of the Clyde, the mica-slates dip towards the S.E., this dip being exactly reversed on both sides of the great valley occupied by the waters of Loch Fyne. The block of intervening land in which this change takes place is happily intersected by a cross glen, which presents a magnificent section of the anticlinal ridge; ably and accurately described by Sir Roderick Impey Murchison in his paper communicated to the Society*.

This anticlinal has no aspect of being caused by any central mass of granite throwing off the strata in opposite directions. I do not merely mean that no such central mass makes itself *visible*, but that the regularity of the reverse dips, and the great extent longitudinally over which they are preserved, do not suggest any notion of a local upheaving action.

I now come to the special subject of this paper,—the structure of the next dividing block of land between two great valleys, viz. between Loch Fyne on the one side and Loch Awe upon the other; embracing what I have called the granitic district of Inverary. I am best acquainted with it, of course, in the immediate neighbourhood of Inverary, but sufficiently so throughout its entire length of some twelve or fifteen miles to feel pretty sure of the essential uniformity of its structure throughout.

I have already mentioned that the strata on *both* sides of Loch Fyne preserve the same north-western dip which they first assume halfway between the Clyde and Loch Fyne. This fact will at once be observed by the geologist who ascends that arm of the sea, and will account to him for some peculiar features in its scenery. Its bed being in the hollow between strata which dip at a high angle, but are conformable with each other and with the line of the Loch, one bank, of course, presents the escarpment, and the other the sloping side. Accordingly, along the upper reach of Loch Fyne, the right or more southern bank presents a steep but smooth and somewhat unbroken ridge, whilst the more northern bank has a much more varied and cliffy aspect; partly due to the escarpment side of the mica-slates, and partly to the frequent alternations of these with intrusive masses of a close-grained porphyritic granite.

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* Quart. Journ. Geol. Soc. vol. vii. pp. 168, 169.

It is the relative position which these two rocks occupy with reference to each other, and the manner in which they are associated, that constitutes the great peculiarity of this district.

We have seen that in the ridges between the Clyde and Loch Fyne, where there is a great anticlinal effected from some cause or another, there is no appearance of any intrusive rock; and we shall now find, that between Loch Fyne and Loch Awe, where there is a perfect conformity in the dip of the stratified slates, there the intrusive rocks are nevertheless developed in great force.

The summit ridge of this district (see fig. 1) is a ridge of mica-slate. It falls rapidly into the basin of Loch Awe, the dip of the strata being steeper along the line of greatest elevation, which runs far back from Loch Fyne, and much nearer to Loch Awe. The intervening space between this summit ridge and Loch Fyne is occupied by a series of lower ridges, in general diminishing in height as they approach the Loch. The *tops* of these ridges are granite; *but the tops only*. Both at their back and on their front, the stratified rocks ascend generally to more than half their height, as well as occupy the whole of the intervening hollows. In short, these granite tops may be said to be *interstratified* on a gigantic scale with the mica-slates; the latter always presenting the same dip and the same general direction. At many spots the line of junction is easily accessible; and the igneous and stratified rocks may be seen, surface to surface, in undisturbing contact with each other.

The general character of this peculiar association of the granite with the mica-slates will be best understood by an ideal section of the district (fig. 2).

Before venturing upon any suggestion

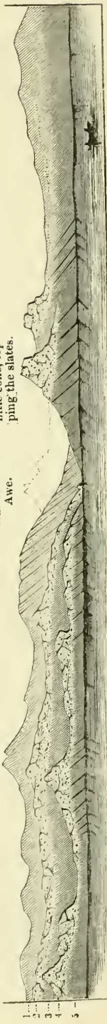
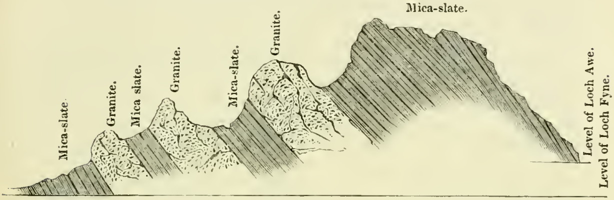

Duniquoich; a remarkable granitic cone, topping the slates.
Ben Cruachan, on the other side of Loch Awe.
Inverary Castle.
4. 1st granitic ridge.
5. Mica-slate.
1. Summit ridge; mica slate.
2. 2nd granitic ridge
3. Mica-slate between two ridges.
1
2
3
4
5

Fig. 1.—*Diagram-sketch of the Inverary District, as seen from Loch Fyne.* Length about 6 miles.

as to the possible cause of such an association of these two rocks, there is one preliminary question which must be either settled by proof, or passed over as not really admitting of any serious doubt; I mean the question of the sedimentary origin of the mica-slates. On this point I can only say, that there appears to me to be every proof except one—the remains of organic life. Nothing can be more complete and regular than the stratification of these rocks; and if there be any other mode whereby such a mechanical arrangement of earthy matter can be effected than that of aqueous deposition, it is a mode of which we have no knowledge. There are the same alternations, which prevail in all other sedimentary rocks, of siliceous, shaly, and calcareous beds; and in respect to the latter, I have had the benefit of examining some limestone strata in this district, along with Sir Roderick Murchison, which were pronounced by him to be not very much more crystalline than some of the limestones of the older rocks which are so abundant in their oceanic fossils.

Fig. 2.—*Ideal Section of the Inverary District.*



The absence of organic remains, however, is of course no real stumbling-block in the way of our conclusion, as it is perfectly consistent with our knowledge of actual facts, that such remains, if they ever existed, may well have been obliterated by metamorphic action; and further, because it is equally consistent with theories having at least some probability, that in these very ancient rocks we should find evidences of a period anterior to the introduction of organized beings to our planet.

Taking for granted then the sedimentary origin of the mica-slates, and therefore the comparative horizontality of their first position, it becomes a question of much geological interest, how they came to assume such a highly inclined position, and how such masses of intrusive igneous rock came to be interposed between their beds, without interrupting their general conformability of dip and of direction; the igneous and the aqueous rocks assuming the position, as it were, of contemporaneous formations.

With igneous rocks of another class, this is no unknown phænomenon; sheets of trap or lava interposed between the beds of sedimentary rocks are not unfrequent; and a remarkable example has been brought under the notice of this Society by Professor E. Forbes, in reference to the oolites of Skye. But the cause of such a conjunction is easy of explanation. Sheets of lava when once poured out are disconnected from the central source from which they came, and if so poured out on the bed of the sea, where strata are in the course of formation, and where similar strata continue to be formed after this event, there is no difficulty in seeing that they may preserve through all time and all changes, their original conformability with the rocks with which they are thus associated.

But can we reason in the same way in respect to masses of granite? Supposing them—which it is very difficult to do—to have been originally poured out upon the bed of the sea in which the slates were forming, what forces can have acted so equally upon thin crusts of sedimentary rock, and upon the deep-seated, deep-rooted hills of granite, that they should maintain through subsequent periods of great disturbance exactly the same relative position?

But, although I think such a supposition would at once appear in the highest degree improbable to any one who looks at the shapes and position of these great granitic masses, with due attention to what we know of the nature and origin of this kind of rock, as distinguished from lavas; there are some other circumstances which seem to me to offer decisive proof that such was not the mode in which the two rocks came to occupy their present relative position.

In the first place, we have clear evidence that the strata of the mica-slate *were not in the course of being deposited* when the granites rose; but that they *had already been consolidated* into hard and sharp fractured rocks, from the fact that fragments of these strata are found imbedded in the midst of the granite—caught up and involved in the melted mass. At a quarry of granite in the immediate vicinity of the town of Inverary, this is of very frequent occurrence; the fragments of slate being of various sizes; the granite fitting closely in to every angle of the broken edges.

Another decisive evidence of the posteriority of the granite to the complete consolidation of the mica-slates is supplied by a circumstance, of which, however, I have only seen one example; viz. a vein or string of granite running for a few feet across the bedding of the slates, at a point where the overlying strata are in close contact with the back of a granitic hill.

I take it, therefore, to be sufficiently proved, that the granite of this district is posterior to the mica-slates; and not only posterior to their deposition, but so immensely posterior, that the slates had already assumed very much the same mineral character which they have at the present day*. The question then comes to be, how such masses of intrusive rock can have effected that intrusion with so little disturbance to the conformability of the strata through which they rose?

One supposition is, I apprehend, at once excluded by the facts, viz. that the granites had burst up through the strata when they were still in a comparatively horizontal position, because in that case the intrusive force would have been exerted more or less nearly at right angles with the planes of stratification; and wherever such a force was exerted with success, those strata must have been violently broken and disturbed, as is so frequently the case elsewhere around the flanks of granitic hills.

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* At certain points the metamorphic strata seem to have been still further metamorphosed by contact with the granite.

To account for the phænomena which have been described, we must suppose the intrusive force to have acted under such conditions as regards the slates, that the planes of their stratification presented to that force the *lines of least resistance.*

No doubt there are conditions under which the planes of stratification would be also the planes of least resistance to liquid matter acting from below, although they had not lost their original horizontality,—conditions such as those already referred to, under which trap, rising through perpendicular fissures, is afterwards spread out laterally in sheets, either between, or on the top of, sedimentary strata. But I have already pointed out certain considerations which go far to show that such conditions are not applicable to the case before us; first, in respect of the difference between such sheets of trap and the irregular masses of granite; secondly, in respect of the difficulty of accounting in the latter case for the parallel position of the slates and granites being retained through changes during which the original horizontality was lost.

The situation of these rocks can be best explained, as it appears to me, if we adopt a supposition which it is the object of this paper to suggest to the Society, and which is also, I think, most reconcileable with the other phænomena of the district.

I account for the granitic masses occupying the position they now do in respect of the inclined strata of mica-slate, by supposing that the falling in of the mica-slates from an horizontal to an inclined position, and the rise of the granites along the loosened planes of stratification, were *connected* and *simultaneous* events. Such a falling in of the stratified rocks would have at once the effect of loosening the adhesion of their mutual surfaces, of causing them to slide off, open out, or otherwise separate from each other, and of forcing up the melted granites into which they fell. The present relative position of the sedimentary and igneous rocks, as if they were of contemporaneous origin, would be thus explained. Contemporaneous as regards *origin*, I have endeavoured to show they cannot be; but contemporaneous they really are, on the supposition above made, as regards their present relative position; inasmuch as the same movement which sunk the one, brought the other up to light.

It seems to me that one of the main features, not merely of the granitic district of Loch Fyneside, but, as before observed, of the greater part of the county, greatly tends to strengthen this supposition; I mean the prevalence of one direction of dip over extensive areas of country, pointing to some general cause operative over a wider field, and with greater equality of effect, than the mere local upheaval of eruptive rocks. Generally, where we have the uptilting of sedimentary rocks unequivocally due to such eruptions, we have evidence of repeated movements more or less of a local character, producing frequent changes of direction as well as of degrees of inclination in the disturbed strata. In the mica-slates of a large part of Argyllshire we have regular anticlinal dips, ranging with remarkable equality and uniformity along considerable lines of country; we have *no* intrusive rocks where a section is afforded of an anticlinal ridge to the depth of some 1500 feet; and where we do meet with the intrusive rocks, we find them not *causing*, but themselves *conforming* to the dip.

I do not apprehend that he who makes such a suggestion can be legitimately called upon to go farther and account for the falling inwards of the mica-slates.

It is not the object of this paper to connect the local phænomena to which it refers with any general theory as to the origin of mountainous irregularities on the surface of the earth. The universal applicability of any one of these theories seems hardly consistent with the evidences of variety which mountainous districts present, as regards almost all the circumstances of their first and successive elevations. But, though there are many conceivable conditions under which the action of gravity might have produced such a falling in of the stratified crust from the withdrawal of internal support, it is impossible not to be struck by the explanation which the "shrinkage" theory of M. Elie de Beaumont and others would afford of the whole structure of this part of Scotland. The mineral character of the mica-slates has been long recognised as in all probability due to the metamorphic action of heat; and I have already shown that there are evidences of this mineral character having been fully acquired before the eruption of the granites. That it is not due to that eruption is farther evident from the fact of its prevalence and uniformity where no such rocks appear at all. It is not, therefore, an improbable supposition, considering the evidence which these rocks afford us, that they had been exposed to a very high temperature from some great general cause, widely operative over the surface of the planet; and if that heat were a decreasing one, shrinkage or contraction of the subterranean masses would inevitably result; which again would be followed by collapses inwards of the outer crust. At the time when these collapses apparently took place in the county of Argyll, the subterranean heat was still so near and so great, that the falling in of the strata to the depth of some 1500 or 2000 feet was sufficient, as we have seen, to force up along their surfaces great masses of granite, so little cooled as to be in a viscous, if not in an actually liquid state.

It would be a matter of much interest, if the crystalline rocks of the Highlands, which seem to belong to an age primæval even as regards the long æras of geology, should be found thus pointing to phænomena of a primæval character.